

IN THE CLAIMS

What is claimed is:

- 1 1. A semiconductor device on a silicon substrate, having a device structure including an
2 insulating film formed from gas containing carbon, comprising:
3 a silicon nitride film formed between the insulating film and the
4 silicon substrate for preventing carbon from diffusing to the silicon substrate.
- 1 2. The semiconductor device according to claim 1, wherein:
2 the insulating film includes tantalum oxide (Ta_2O_5).
- 1 3. The semiconductor device of claim 2, wherein:
2 the semiconductor device is a dynamic random access memory having
3 a memory cell capacitor film including the tantalum oxide.
- 1 4. The semiconductor device of claim 3, wherein:
2 the semiconductor device includes a contact which penetrates an
3 interlayer insulating film and is electrically connected with a diffusion layer in
4 the silicon substrate; and
5 the silicon nitride film is formed on the silicon substrate as a carbon
6 diffusion preventing film while traversing a region except a portion for
7 providing the electrical connection between the contact and the diffusion
8 layer.

09981402-101701
FDZTPT 20170500

1 **5.** The semiconductor device of claim 3, wherein:

2 the semiconductor device includes a contact that penetrates a first
3 interlayer insulating film and is electrically connected with a diffusion layer
4 formed in the silicon substrate and a capacitor contact that is interposed
5 between a lower electrode of the memory cell capacitor and the contact while
6 penetrating a second interlayer insulating film and a third interlayer insulating
7 film; and

8 the silicon nitride film is formed on the third interlayer insulating film
9 while traversing a region except a connection portion between the lower
10 electrode and the capacitor contact.

1 **6.** The semiconductor device of claim 3, wherein:

2 the semiconductor device includes a contact that is electrically
3 connected with the diffusion layer formed in the silicon substrate while
4 penetrating the first interlayer insulating film;

5 the contact is electrically connected to a capacitor contact that is
6 interposed between a lower electrode of the memory cell capacitor and the
7 contact while penetrating a second interlayer insulating film and a third
8 interlayer insulating film for providing an electrical connection between the
9 lower electrode and the contact; and

10 the silicon nitride film is formed between the second and third
11 interlayer insulating films.

1 7. A method for manufacturing a semiconductor device on a silicon substrate, having a
2 device structure including an insulating film formed from gas containing carbon, comprising
3 the step of:

4 forming a silicon nitride film between the insulating film and the
5 silicon substrate for preventing carbon from diffusing to the silicon substrate.

1 8. The method for manufacturing a semiconductor device of claim 7, further including
2 the steps of:

3 forming a word line on a silicon substrate;

4 forming the silicon nitride film over the entire surface of the substrate
5 including the word line;

6 forming a first interlayer insulating film on the silicon nitride film;

7 etching the first interlayer insulating film to form a cell contact hole
8 with an etching method selective for the silicon nitride film to expose the
9 silicon nitride film at a bottom of the cell contact hole;

10 selectively etching the silicon nitride film exposed at the bottom of the
11 cell contact hole to expose the silicon substrate; and

12 forming a cell contact plug in the cell contact hole.

1 9. The method for manufacturing a semiconductor device of claim 8, further including
2 the steps of:

3 forming a first capacitor electrode electrically connected to the cell
4 contact plug;

forming the insulating film; and

forming a second capacitor electrode on the insulating film.

10. The method for manufacturing a semiconductor device of claim 9, wherein:

the insulating film includes tantalum oxide (Ta_2O_5).

11. The method for manufacturing a semiconductor device of claim 7, further including the steps of:

forming a word line on a silicon substrate;

forming a first interlayer insulating film on the silicon substrate including the word line;

forming a cell contact plug through the first interlayer insulating film to provide an electrical connection with a diffusion layer in the silicon substrate;

forming a second interlayer insulating film on the first interlayer insulating film;

forming a bit line on the second interlayer insulating film;

forming a third interlayer insulating film on the second interlayer insulating film including the bit line;

forming a capacitor contact plug through the second and third interlayer insulating films to provide an electrical connection to the cell contact plug; and

forming the silicon nitride film on the third interlayer insulating film

18 and capacitor contact plug.

1 **12.** The method for manufacturing a semiconductor device of claim 11, further including
2 the steps of:

3 forming a fourth interlayer insulating film on the silicon nitride film;

4 forming a capacitor formation section in the fourth interlayer
5 insulating film to expose the silicon nitride film; and

6 etching the exposed silicon nitride film to expose the capacitor contact
7 plug.

1 **13.** The method for manufacturing a semiconductor device of claim 12, further including
2 the step of:

3 forming a capacitor including the insulating film in the capacitor
4 formation section.

1 **14.** The method for manufacturing a semiconductor device of claim 7, further including
2 the steps of:

3 forming a word line on a silicon substrate;

4 forming a first interlayer insulating film on the silicon substrate
5 including the word line;

6 forming a cell contact plug through the first interlayer insulating film
7 to provide an electrical connection with a diffusion layer in the silicon
8 substrate;

9 forming a second interlayer insulating film on the first interlayer
10 insulating film;

11 forming a bit line on the second interlayer insulating film;

12 forming a third interlayer insulating film on the second interlayer
13 insulating film including the bit line;

14 forming the silicon nitride film on the third interlayer insulating film;

15 and

16 forming a capacitor contact plug through the second and third
17 interlayer insulating films and the silicon nitride film to provide an electrical
18 connection to the cell contact plug.

1 **15.** The method for manufacturing a semiconductor device of claim 14, further including
2 the step of:

3 forming a capacitor including the insulating film and having a
4 capacitor electrode electrically connected to the capacitor contact plug.

1 **16.** The method for manufacturing a semiconductor device of claim 7, further including
2 the steps of:

3 forming a word line on a silicon substrate;

4 forming a first interlayer insulating film on the silicon substrate
5 including the word line;

6 forming a cell contact plug through the first interlayer insulating film
7 to provide an electrical connection with a diffusion layer in the silicon

8 substrate;
9 forming a second interlayer insulating film on the first interlayer
10 insulating film;
11 forming a bit line on the second interlayer insulating film;
12 forming the silicon nitride film on the second interlayer insulating film
13 including the bit line;
14 forming a third interlayer insulating film on the silicon nitride film;
15 etching the third interlayer insulating film to form a contact hole and
16 expose the silicon nitride film at a bottom of the contact hole;
17 etching the silicon nitride film at the bottom of the contact hole to
18 expose the second interlayer insulating film;
19 etching the exposed second interlayer insulating film at the bottom of
20 the contact hole to provide a capacitor contact hole including the contact hole;
21 and
22 forming a capacitor contact plug through the second and third
23 interlayer insulating films to provide an electrical connection to the cell
24 contact plug.

1 17. The method for manufacturing a semiconductor device of claim 16, further including
2 the step of:

3 forming a capacitor including the insulating film and having a
4 capacitor electrode electrically connected to the capacitor contact plug.

1 **18.** A method for manufacturing a semiconductor device on a silicon substrate, having a
 2 memory cell including a capacitor insulating film formed from gas containing carbon,
 3 comprising the step of:

4 forming a silicon nitride film between the capacitor insulating film and
 5 the silicon substrate for preventing carbon from diffusing to the silicon
 6 substrate.

1 **19.** The method of manufacturing the semiconductor device of claim 18, wherein:
 2 the capacitor insulating film includes tantalum oxide (Ta_2O_5).

1 **20.** The method of manufacturing the semiconductor device of claim 19, wherein:
 2 the capacitor includes an electrode having a hemi-spherical grain
 3 structure.